SUMMARY OF FINDINGS ON

THE SITING OF PROPANE AND NATURAL GAS

TRANSPORTATION FUEL FACILITIES

MARCH, 1988

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THE SITING OF PROPANE AND NATURAL GAS TRANSPORTATION FUEL FACILITIES

MARCH 1988

Prepared by the R.F. Webb Corporation of Ottawa, Ontario
in conjunction with the GIC

Submitted to:

The Minister of Consumer and Commercial Relations
555 Yonge Street, Toronto, Ontario M7A 2H4

By:

The Chairman of the Government-Industry Committee
On the Siting of Propane and Natural Gas
Transportation Fuel Facilities (GIC)
Ministry of Consumer and Commercial Relations,
4th Floor, 3300 Bloor Street West, Toronto, Ontario M8X 2X4

Ontario
Ministry of Consumer and Commercial Relations
Ministère de la Consommation et du Commerce
Technical Standards Division
Division des normes techniques

3300 Bloor Street West
Shipp Centre - West Tower
4th Floor
Toronto, Ont. M8X 2X4

(416) 234-6029

March 31, 1988

The Honourable William Wrye
Minister of Consumer and
Commercial Relations
555 Yonge Street
Toronto, Ontario
M7A 2H6

Dear Minister:

On behalf on the Government-Industry Committee on the Siting of Propane and Natural Gas Transportation Fuel Facilities, I am pleased to enclose a copy of the interim report entitled "Summary of Findings on the Siting of Propane and Natural Gas Transportation Fuel Facilities".

Respectfully,

R.H. Clendining

R.H. Clendining
Chairman

Enclosure

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PREFACE

This is a report of the findings of the Government-Industry Committee on the Siting of Propane and Natural Gas Transportation Fuel Facilities (GIC). It relates to the safety record and current regulation of propane, natural gas for vehicles (NGV), and gasoline at public refuelling stations. The report is based on facts collected by Dr. R.F. Webb, consultant to the GIC, under the Committee's direction and in the context of its terms of reference (Exhibit 1). It also reflects facts found by Dr. Webb with respect to propane and natural gas conversion and repair facilities.

The members of the Committee collectively agree that the information contained is useful in assessing the safe storage, transfer, and use of the fuels and should be made accessible to the public.

The Committee plans to issue an interim report of recommended actions as soon as possible, following an appropriate period to allow for comments from the public on this report of the findings.

The membership of the Committee is attached as Exhibit 2.

Exhibit 1

GOVERNMENT/INDUSTRY COMMITTEE ON SITING OF PROPANE AND NATURAL GAS TRANSPORTATION FUEL FACILITIES

TERMS OF REFERENCE

1.0 BACKGROUND

In November 1986, a propane explosion in a taxi repair garage located at a fuelling station on Weston Road caused property damage. The garage was not licensed to do propane work. While the presence of propane storage and dispensing equipment on the site had no relationship to the explosion, the incident prompted concern among municipalities whether the existing provincial safety code setback requirements provide sufficient separation from adjacent residential property. In response, some municipalities have initiated reviews of existing zoning by-laws governing the location, site-plans, and hours of operation of fuel outlets and automobile service stations.

Residents have also expressed concern at the noise, odour, and traffic patterns associated with gaseous fuel outlets. It is not clear whether these issues apply exclusively to gaseous fuel outlets.

The Ministry of Energy (MENG) continues to encourage the use of alternative transportation fuels (ATFs) as a means of securing Ontario's energy future, reducing transportation costs as well as Ontario's dependence on imported oil. The Ministry of Consumer and Commercial Relations (MCCR) continues to ensure the safe storage, handling, and utilization of hydrocarbon fuels; it administers regulations that are considered among the most stringent in the world. Both Ministries would like to ensure the continuing availability of ATFs with maximum public safety.

The existing ATFs are propane, natural gas, alcohols (neat or blended), electricity, and hydrogen. Of these ATF options, the two gaseous fuels (auto-propane and natural gas for vehicles) are the only alternatives with any substantive market presence at this time. Consequently, the committee will consider only these two gaseous fuels -- auto-propane, and natural gas for vehicles (NGV).

An entire industry has grown up around the provision of propane and natural gas technology and services. In addition to the $150 million provided by the Province in tax incentives, the propane and natural gas industries have invested a further $150 million or more in auto-propane and NGV, and have created thousands of permanent jobs.

It is proposed that a government/industry committee, with consumer participation, be established to examine the concerns of the municipalities, to review the pertinent safety codes in Ontario, and to assist municipalities to resolve their concerns. There are differences in characteristics among the available motor fuels, and the relevant regulations and safety record of each will be gathered and compared.

The Ministry of Energy and the Propane Gas Association of Canada (PGAC)

are commissioning a separate study of propane vehicle safety, which will complement the work of the committee. The PGAC/MENG study focuses exclusively on auto-propane and is concerned primarily with the vehicle. The work of this committee, on the other hand, includes both auto-propane and NGV, and concentrates on the fuelling and service infrastructure and regulations. Participation by MENG and PGAC in both projects will ensure coordination.

2.0 SCOPE AND OBJECTIVES

The scope of the committee is intentionally broad. Ontario has prided itself in having an ATF program that is exemplary in Canada, if not the world. In encouraging ATFs, public safety has been held to be paramount.

It is not intended that the members of the committee do the necessary analysis -- a consultant will be retained for that purpose. The committee members will serve in an advisory capacity to the Minister and will have a decision making role with respect to the content of the final report. The consultant will gather and present to the committee such information as it requires to draw its conclusions and make its recommendations.

The first question to be resolved by the committee is whether the existing pertinent safety codes are adequate. The committee will consider the Ontario safety codes for auto-propane and NGV separately in comparison with those in other jurisdictions, and also in comparison with the codes for conventional fuels such as gasoline. The review will incorporate the qualification and certification of the persons handling the various fuels, as well as the technology. To be fair to the industry, which has invested heavily and created thousands of jobs in Ontario, it is important to consider propane and natural gas in the context of the level of risk that society accepts for other fuels (e.g. gasoline) and in other uses (e.g. natural gas space heating and propane barbecues).

The committee must consider both the exposure to risk and the consequences of an accident. Therefore, it will review the experience of various jurisdictions with actual incidents at fuel transfer facilities, conversion centres, and automobile service centres. It will be important to exclude minor infractions in this analysis.

In its report, the committee may recommend public education measures, technical training programs, additional research into safety standards and incident control, levels of enforcement required to make safety codes effective, and model by-law provisions and guidelines for their implementation by municipalities. While safety will be the primary focus, it is recognised that noise, odour, and traffic disruption are also issues of concern to municipalities that can be dealt with in the same forum.

Specifically, the committee shall:

2.1 Define the needs of municipalities, the Province, and the propane and natural gas industries.

2.2 Review the pertinent auto-propane and NGV safety regulations in other Canadian jurisdictions, the USA, Italy, the Netherlands, Japan, and New Zealand, comparing them to Ontario's regulations.

2.3 Review accident/incident records in the jurisdictions noted in point 2.2, and compare this experience with that of Ontario.

2.4 Review the training programs and technical qualifications required for handling auto-propane and NGV in Ontario, compared to other jurisdictions.

2.5 Determine the need for a public education program on auto-propane and NGV.

2.6 Review Ontario safety records and regulations governing conventional liquid fuels, and compare them to those for auto-propane and NGV.

2.7 Define the need for further research and analysis of incident mitigation measures.

2.8 Review the extent of (a) noise and air pollution, (b) traffic disruption, and (c) other non-safety matters of municipal concern associated with propane, NGV, and other fuel outlets.

2.9 Draft guidelines for municipalities to regulate the siting control and subsequent operation of auto-propane and NGV outlets, conversion centres, and motor vehicle repair centres.

2.10 Recommend a course of action to the Minister of Consumer and Commercial Relations, including specific reference to:

(a) implementation of the proposed guidelines for municipal regulation of siting and operation of auto-propane and NGV facilities;
(b) pertinent safety regulations in Ontario relating to auto-propane and NGV outlets, including setback distances for storage tanks;
(c) the need for public education programs about auto-propane and NGV safety, and the need for revisions to existing technical training courses;
(d) any other matter agreed to by the committee.

3.0 COMMITTEE COMPOSITION

The committee should comprise all those organisations with an interest in the outcome of its deliberations. This includes the Provincial Government, municipal government, and the propane and natural gas industries.

The following membership is recommended:

Ministry of Consumer and Commercial Relations (Fuels Safety Branch)
Ministry of Energy
Ministry of the Environment
Ministry of Municipal Affairs (Community Planning Branch)
Ministry of the Solicitor General (Office of the Fire Marshal)
Association of Municipalities of Ontario
Consumers' Association of Canada
Ontario Natural Gas Association
Ontario Petroleum Association
Propane Gas Association of Canada

4. PROCEDURE

The committee will be chaired by the Director, Fuels Safety Branch, Ministry of Consumer and Commercial Relations. An Executive Secretary will be supplied by the Ministry of Energy. A consultant will be hired to manage the committee process, act as a recording secretary, conduct appropriate reviews, and make proposals for the committee to consider.

It will be necessary for the consultant to provide concise but detailed information as input to meetings of the committee. In addition to managing the process, therefore, the consultant will provide the committee with information on each of the subjects discussed in Section 2. It will also be the consultant's job to prepare draft reports summarising the committee's conclusions and recommendations to be forwarded to the Minister of Consumer and Commercial Relations.

The committee members will be of sufficient seniority to represent the views of their peers and to make decisions on behalf of their organisations. As time is critical, the group will meet as required.

5. BUDGET AND TIME FRAME

The final report is expected from the committee by September 30th, 1987. The report will be presented to the Minister of Consumer and Commercial Relations, recommending steps to be taken by the Province. Copies of the report will be presented simultaneously to all the participating organisations.

The final report may recommend further analysis or research. The conduct of such work would form a subsequent project, possibly but not necessarily involving any or all of the committee members.

The Ministry of Energy will contribute 50 per cent of the cost of this project, to be administered by the Ministry of Consumer and Commercial Relations. Details of cost-sharing with the industry are being negotiated.

87/07/15

Exhibit 2

MEMBERSHIP OF THE GOVERNMENT-INDUSTRY TECHNICAL COMMITTEE ON SITING OF PROPANE AND NATURAL GAS TRANSPORTATION FUEL FACILITIES

Chairman:	Robert H. Clendining Director, Fuels Safety Branch Ministry of Consumer and Commercial Relations 4th Floor, West Tower, 3300 Bloor Street West Etobicoke, Ontario M8X 2X4 (416) 234-6029
Executive Secretary:	Ed Grzesik Codes and Standards Adviser Ministry of Energy 10th Floor, 56 Wellesley Street West Toronto, Ontario M7A 2B7 (416) 965-0297
Recording Secretary and Committee Consultant	Reg F. Webb R.F. Webb Corporation 1011 - 5 Prince of Wales Drive Ottawa, Ontario K2C 3K1 (613) 224-8460

John Bateman, Fire Marshal, Ministry of the Solicitor General, 3rd Floor, 7 Overlea Boulevard, Toronto, Ontario M4H 1A8
(416) 965-4844
Alternate: Joshy Kallungal, Assistant Chief, Technical, Research and Consulting Services, Office of the Fire Marshal, Ministry of the Solicitor General, 3rd Floor, 7 Overlea Boulevard, Toronto, Ontario M4H 1A8
(416) 965-4852

Drew Brims, Ontario Petroleum Association, Propane Representative, Suncor, 25 Overlea Boulevard, Building #1, Toronto, Ontario M4H 1B5
(416) 733-7484

Don Edwards, Propane Gas Association of Canada, Executive Vice President, Superior Propane Inc., 8474 Keele Street, Concord, Ontario L4K 2S5
(416) 669-9732
Alternate: George Olah, Director, Marketing Services, Superior Propane Inc., 8474 Keele Street, Concord, Ontario L4K 2S5
(416) 669-9732

Frank Faubert, Association of Municipalities of Ontario, Controller, City of Scarborough, 150 Borough Drive, Scarborough, Ontario M1P 4N7
(416) 396-7273

Curt Halen, Senior Planner, Office of the Local Planning Policy, Ministry of Municipal Affairs, 13th Floor, 777 Bay Street, Toronto, Ontario M5G 2E5
(416) 585-6230

Leslie Kende, Supervisor, Noise Assessment and Systems Support Unit, Environmental Approval and Land Use, Planning Branch, Ministry of the Environment, 9th Floor, 135 St. Clair Avenue West, Toronto, Ontario M4V 1P5
(416) 323-4458

Tanis Mathers, Chairman of the Energy Committee, Consumers' Association of Canada, 10 Brentwood Place, London, Ontario N6G 1X6
(519) 471-8460
Alternate: Al Seskus, Department of Civil Engineering, University of Toronto, 35 St. George Street, Toronto, Ontario M5S 1A4
(416) 481-6864

Jack Patriarche, Program Adviser, Alternative Fuels Demonstration, Ministry of Energy, 8th Floor, 56 Wellesley Street West, Toronto, Ontario M7A 2B7
(416) 965-2984
Alternate: John Hutchison, Senior Program Adviser, Alternative Fuels Demonstration, Ministry of Energy, 56 Wellesley Street West, Toronto, Ontario M7A 2B7
(416) 965-0367

Mel Patterson, Propane Gas Association of Canada, Vice President, Ontario Region, ICG Liquid Gas, 800A Denison Street, Markham, Ontario L3R 5M9
(416) 477-3155
Alternate: Ron Shorten, Director, Safety, Inter-City Gas Corporation, Inter-City Gas Building, 444 St. Mary Avenue, Winnipeg, Manitoba R3C 3T7
(204) 934-3350

Paul Pinnington, Managing Director, Ontario Natural Gas Association, Suite 1104, 77 Bloor Street West, Toronto, Ontario M5S 1M2
(416) 961-2339
Alternate: Bruce Rogers, Manager, NGV Sales, Union Gas Limited, 50 Keil Drive North, Chatham, Ontario N7M 5M1
(519) 436-4576

James A. Smith, Association of Municipalities of Ontario, Mayor, Town of Flamborough, Box 50, 163 Dundas Street East, Waterdown, Ontario L0R 2H0
(416) 689-7351

Alan Tonks, Association of Municipalities of Ontario, Mayor, City of York, 2700 Eglinton Avenue West, Toronto, Ontario M6M 1V1
(416) 394-2400

For Information Only:

Mac Dunbar, Executive Director, Association of Municipalities of Ontario, Suite 805, 100 University Avenue, Toronto, Ontario M5J 1V6
(416) 593-1441

Harold Kivi, Executive Director, Transportation Regulation Operations Division, Ministry of Transportation and Communications, Main Floor, East Building, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8
(416) 235-4785

87/07/28

EXECUTIVE SUMMARY

A severe incident involving propane occurred in November 1986 at a taxi repair facility located at Weston Road in the City of York, Metropolitan Toronto, which was not licensed for propane vehicle conversion or repair. The incident occurred when the propane fuel lines on a taxi were severed during removal of the propane equipment from a damaged taxi. The leak of propane ignited, causing an explosion, injuries to two mechanics in the building and damage estimated at $300,000, principally to the garage. Some windows were broken and minor damage was reported to property within a 100 metre radius of the incident site. The integrity of the fuel storage and refuelling facility at the site was not impaired. Although the public and municipalities have expressed concern about propane storage tank setbacks, the explosion and consequent damage at the Weston Road incident was unrelated to the setback of the propane storage tank on that site.

The illegal repair operation resulted in prosecution of the garage owner by the Fuels Safety Branch and the imposition of a fine. The incident received wide publicity and initiated reviews by the City of York and certain other municipal councils in Ontario of by-laws on auto-propane and natural gas for vehicles (NGV) facilities.

In response to this activity, the Government-Industry Committee on the Siting of Propane and Natural Gas Transportation Fuel Facilities (GIC) was struck to review the safety regulations in Ontario and to provide guidelines for the Ontario municipalities. The GIC has issued an interim report on its findings on safety aspects of the storage and distribution of automotive propane and NGV and the conversion and repair of propane and NGV vehicles. The interim report is a first step toward identifying issues and opportunities for improvements in the safety of auto-propane and NGV in Ontario and developing guidelines for Ontario municipalities' consideration in drafting by-laws on the siting and local regulation of auto-propane and NGV.

Use of propane has grown rapidly in response to government tax incentives and promotion. There is now a well-established infrastructure

for the distribution of the fuel and for vehicle conversions to propane. NGV is at an earlier stage of commercial development.

In Ontario, 76 incidents involving auto-propane have been reported by the Fuels Safety Branch since 1980 at propane refuelling stations and conversion/repair facilities. The incidents were primarily at retail fuelling sites and most occurred during refuelling of vehicles or filling of portable barbecue cylinders. Other incidents occurred during vehicle repair or conversion operations. No fatalities were reported in Ontario or elsewhere in Canada from these operations.

The incidents at propane refuelling stations did not involve catastrophic equipment failures or large releases of propane. No injuries or property damage were noted outside the fuel station area. The frequency of incidents at retail propane service stations has decreased over time, despite the increase in the use of auto-propane. The incident rate is still higher than that reported for gasoline after allowance is made for the different scale of use of the two fuels.

Incidents at Ontario propane repair facilities, although few in number, were more severe than those at refuelling stations and damage was reported on occasion to adjacent property. The most severe incident at repair facilities in Ontario was that at the unlicensed Weston Road taxi garage.

No incidents involving NGV have been reported by the Fuels Safety Branch or the Office of the Fire Marshal of Ontario.

Risk assessment studies conducted in the Netherlands and the U.S.A. were examined in order to quantify the frequency of certain types of incidents at refuelling stations and their effects. The potential for injuries and fatalities from propane refuelling is judged to be no higher than that accepted by the public and employees for a number of other conveniences and occupations. No risk assessment studies have

been conducted on propane or NGV vehicle repair and conversion facilities, but incident analysis indicates that measures can be taken to reduce the possibility and severity of accidents in such enclosed environments.

Current Ontario regulations for the siting of propane equipment are comparable to those used elsewhere in Canada and the U.S.A. Ways to improve safety and public perception have been investigated, and include such options as burial of propane storage tanks and replacement of barbecue cylinder filling by cylinder exchange at sites in congested areas, such as those close to residences.

Ontario regulations relating to the certification of personnel and licensing of facilities handling propane are second-to-none, but the incident experience in Ontario indicates a need for improved training and supervision of personnel. Similar regulations are pending for NGV.

Public perception of propane and NGV would be improved by knowledge of the benefits and relative safety of these fuels compared to conventional fuels.

1. BACKGROUND

1.1 Objectives

The principal objectives of the Government-Industry Committee's (GIC) investigation of the siting of propane and natural gas transportation fuel facilities are:

i. To report to the Minister of Consumer and Commercial Relations on the safety of propane and NGV at public fuel transfer and vehicle conversion sites.

ii. To develop a set of guidelines which may be recommended to the municipalities of Ontario for their consideration in drafting municipal by-laws concerning the sites and local regulation of propane and compressed natural gas fuelling stations, as well as for conversion and repair shops for propane and NGV vehicles to the extent that their jurisdictions permit.

This report summarizes the GIC findings. It includes a comparison of the Ontario regulations for auto-propane and natural gas for vehicles (NGV) to those in other jurisdictions (specifically the Netherlands, the U.S.A., New Zealand, Australia and Italy) and those contained in the Canada Codes (CAN B149.1-M86 for NGV and CAN B149.2-M86 for propane).

The report provides a comparison of the incident record at public service stations, conversion and repair shops for auto-propane and gasoline in these jurisdictions and separately for NGV and gasoline. Ontario regulations and incidents for propane cylinder filling at retail (public) refuelling stations are also addressed.

The report also discusses the findings of hazard analyses conducted in the Netherlands, New Zealand and the U.S.A.

1.2 Definitions

A glossary of terms used in this report is given in the Appendix.

Key characteristics of gasoline and the alternatives, propane and natural gas, which affect safety and handling practices are summarized in Table 1. The most noteworthy differences between the fuels are:

Storage

Gasoline is stored and pumped as a liquid at ambient temperature and pressure.

Propane is a liquid at ambient temperatures only when stored under pressure; release of the pressure results in gasification and cooling of propane. The cooling effect can be seen when propane vapourizes in air, since water vapour in the air freezes to form a visible fog. The strong cooling effect when propane expands from the liquid to the vapour must be taken into account when handling propane, since unprotected hands may suffer freeze burns on exposure to liquid propane.

NGV is stored as a gas under pressure (up to 3600 psi) in steel cylinders, which inherently require rigorous design and installation standards to ensure containment of the fuel at this pressure.

Properties

Gasoline is a complex liquid mixture of combustible hydrocarbons. Spills of gasoline vapourize and mix with air more slowly than propane or NGV and present a somewhat more long-lived fire and explosion hazard than propane and NGV. The hazard is offset somewhat by the visibility of above-ground gasoline spills. Leaks of liquid gasoline from underground storage tanks present an environmental and safety hazard not encountered with propane and NGV.

Table 1

A Comparison of the Characteristics
of Propane, NGV and Gasoline Relevant to Safety

	PROPANE	NGV	GASOLINE
State as stored	Liquid under pressure	Gas under pressure	Liquid
Storage pressure, psig (1)	105–140	2400–3600	Ambient pressure
Density of vapour relative to air = 1.0	1.6	0.56	3.4
Density of liquid relative to water = 1.0	0.58	Not applicable	0.7 to 0.8
Boiling point (^{o}C) (2)	-42	Not applicable	37 to 200
Flammability lower limit volume % in air	2.1	5.3	1.0
" upper " " " " "	9.5	15.0	7.6
Detonation lower limit volume % in air	3.1	6.3	1.0
" upper " " " " "	7.0	13.5	3.3
Auto-ignition temperature, ^{o}C (3)	457	540	328

Notes (1) psig = pounds per square inch pressure, gauge (excess pressure over atmosphere)
(2) The boiling point of propane and gasoline is given at normal pressure. NGV is a gas but natural gas liquifies (to liquid natural gas, LNG) at about -162^{o}C
(3) The minimum temperature necessary to ignite a mixture of the fuel in air.

Propane is heavier than air and spills or leaks from tanks, pipelines and other equipment may produce a cloud of propane vapour which can collect in sewers, gulleys and depressions, presenting a fire and explosion hazard until the propane cloud is diluted with air by mixing to the point where the mixture cannot be ignited.
NGV leaks produce natural gas which is lighter than air. Escaping NGV will therefore rise and mix with air until the gas-air mixture is too dilute to support combustion or an explosion.

Flammability

Gasoline forms a flammable or explosive mixture with air at lower concentrations than propane and much lower than NGV. The concentration range for gasoline combustion (1 to 7.6 volume % in air) is somewhat narrower than for propane and natural gas.

There are differences in the minimum energy required for ignition of gasoline, propane and NGV, but the rate of dispersion of these fuels determines the possibility of ignition.

1.3 Alternative Fuels in Canada

The international oil supply crisis of 1973 and subsequent increases in the price of crude oil up to early 1986 led to the development of a Canadian market for alternative fuels based upon Canada's abundant supply of natural gas and propane.

Governments in Canada have recognized the need to ensure the availability of a range of transportation fuel options to enhance energy security.

The recognized benefits include: the long-term security of supply of Canadian natural gas and propane; the utilization within Canada of these Canadian resources which are available in quantities much greater

than current Canadian demand; the competitive price of the fuels at the retail level and their environmental benefits. Governments and industry have aggressively responded to this alternative fuel opportunity through the development of:

- information to the public on the alternative fuels
- revised regulations and legislation to facilitate the availability and safe use of the alternative fuels
- a preferred road fuel tax status for propane and NGV, which has contributed to lower fuel costs to users of these alternatives to gasoline in Ontario. (On average, the retail price of propane and NGV in Ontario is about 50% that of gasoline)
- tax rebate and incentive programs to reduce financial barriers to vehicle conversion
- extensive capital commitments by industry to expand the fuel distribution and vehicle conversion facilities
- innovative alternative fuel technology.

The outcome in Canada has been acceptance of propane and NGV as viable alternatives to gasoline and diesel. Approximately 125,000 Canadian vehicles now operate on automotive propane and approximately 15,000 vehicles operate on NGV.

1.4 Auto-Propane Growth in Ontario

Development of auto-propane demand in Ontario has been faster than in other provinces, due in part to the high level of financial incentives to convert from gasoline. About 50% of the total propane vehicles in operation are located in Ontario and consumption of auto-propane in Ontario increased from about 50 million litres in 1982 to 287 million litres in 1986 in a period when gasoline consumption at first declined and has only recently returned to the 1982 level of 11.3 billion litres. In 1986 auto-propane sales reached 2.5% of the level of gasoline sales.

The pattern of auto-propane consumption in Ontario has been changing. In the early 1980's fleet use from private fuel storage grew rapidly, but recently retail sales have increased more rapidly and now account for 36% of auto-propane sales in the province. There are now about 1,700 locations licenced to serve the Ontario public with auto-propane compared with about 7,900 public stations retailing gasoline. The number of gasoline service stations has been declining: the 7,900 service stations are over 20% fewer than those reported in the early 1980s.

About 16,000 persons in Ontario are certified as propane refuellers. There are about 500 shops licenced in Ontario to undertake vehicle conversion to propane; some 5,200 individuals are licenced to convert and about 2,800 to convert and certify the conversions. A number of individuals hold both types of certificates.

The growth of auto-propane sales has been accompanied by a growth in sales of propane as a barbecue fuel. Barbecue cylinder refilling is an important service provided at propane service stations.

1.5 NGV Growth in Ontario

Sales of NGV have only recently become significant in Ontario. NGV sales in 1986 were at about 5% the level of propane sales and 0.15% of the gasoline sales volume.

In mid-1987 it is estimated that there were approximately 3,000 NGV vehicles in operation in Ontario. These were predominantly dual-fuel conversions, i.e. vehicles which can be operated on either NGV or gasoline.

The number of public refuelling stations for NGV totalled 34 in mid-1987, but is expected by the industry to double before 1989. There are 44 conversion shops for NGV vehicles employing 320 fitters.

1.6 Increased Public Awareness of Alternative Fuels

The growth in sales and the number of sites serving propane or NGV has generated an increased public awareness of the alternative fuels and in some cases an increased level of complaints. The majority of these complaints are nuisance-related; noise, increased level of traffic and odour are the most frequently cited.

It is noted that the increased public awareness of alternative fuels has not been accompanied by a corresponding increase in public understanding of the properties and benefits of propane and NGV.

2. PROPANE REFUELLING AND VEHICLE CONVERSION INCIDENTS IN ONTARIO

The increase in sales at the new propane sites has led to a higher number of reported incidents compared to normal operations at established gasoline stations. This may be due in part to the problems inherent in starting up new facilities and in the training and experience of station employees, and in part to the fact that propane stations serve both the auto-fuel and barbecue cylinder refilling markets. There is also the possibility that the reporting of spills and other incidents involving propane is more complete than that for gasoline, due to the sensitivity of the fuel suppliers, the Fuels Safety Branch and the public to the propane safety issue. There is strong evidence that the frequency of occurrence of incidents at propane retail stations is being improved over time.

Sixty-nine incidents at refuelling stations were reported in the period 1980-87 by the Fuels Safety Branch, 58 of these at retail service stations and 11 at private (fleet) refuelling facilities. In the same period 7 incidents were reported at shops which repair or convert propane vehicles.

The 58 incidents reported at the public refuelling (retail) facilities were attributed as follows:

Vehicle refuelling operations and equipment	32
Barbecue cylinder refuelling and handling	7
Fuel tank, fuel lines, other on site incidents (including undefined)	19
Total	58

The incident rate at public propane service stations in Ontario increased from 1982 to 1985, paralleling the increase in propane transferred and the increasing number of retail outlets. However, this trend was reversed as the incident rate declined in 1986, presumably in response to experience gained and the impact over time of training and regulations. This trend reversal occurred, despite further increases in the number of retail outlets and the volume of propane sold. The "learning curve" experience is typical of new technologies and was experienced with gasoline in its early days of commercial introduction.

Reported statistics indicate that the number of incidents at private refuelling facilities has also declined over time and is very low compared to that experienced at public service stations. This difference in the incident level reported cannot be attributed solely to the reduced number of refuelling transactions, since the volume of auto-propane transferred at private stations is double that at public stations.

The incident statistics show that the higher incident frequency at public service stations also cannot be attributed to barbecue cylinder filling service which is not available at private fuelling sites. No doubt there is a likelihood of less complete reporting of incidents at private facilities, but the implication is that the difference may be attributed in part to the difference in staff training, supervision and turnover at the two types of vehicle refuelling stations.

2.1 Incidents at Public Propane Refuelling Stations in Ontario

The outcome of the incidents reported during 1980-87 by the Fuels Safety Branch at retail service stations is summarized in Table 2. Table 3 provides comparative data on incidents reported at private propane refuelling stations, Table 4 shows the incidents at retail gasoline service stations, and Table 5 incidents at propane vehicle conversion and repair shops. The key findings on incidents at public propane refuelling stations are:

i. There have been no fatalities due to propane at these sites.

ii. The 58 incidents recorded at these sites did not cause injury to any person or damage to property outside the service station area. (Note the Weston Road incident was not related to refuelling, see p. 16).

iii. Vehicle refuelling operations were the most frequent source of incidents (55%) reported. The filling of portable cylinders was a notable but less frequent source (12%). A variety of incidents involving the fuel storage and dispenser equipment and propane transfer from road tankers to on-site storage accounted for the remainder (33%).

iv. About 62% of the incidents involved a fire. 8 explosions (12% of total incidents) were recorded from 1980-87.

v. The 58 reported incidents were accompanied by 44 injuries, the most frequent of which were fire burns (29, 65% of injuries), but a significant proportion (13, 30%) were freeze burns to employees from contact with leaks of liquid propane most frequently from the "spitter" valve used to control the filling level of propane in vehicle storage tanks.

Table 2
Summary of Propane Incidents Reported in Ontario 1980-87
Public Service Stations

	Vehicle Fuelling	BBQ Cylinders	Other Fuel Storage & Transfer	TOTAL
# Reported Incidents	32	7	19	58
Total Fires	23	6	7	36
Total Injuries	27	6	11	44
Fires without explosions	19	6	5	30
Explosions with/without fires	4	0	3	7
Fire burn injuries	17	6	6	29
Freeze burn injuries	8	0	5	13
Other injuries	2	0	0	2

Table 3
Incidents Reported for Auto-Propane Refuelling at
Private Stations in Ontario 1980-87

# Reported Incidents	11
Total Fires	6
Total Injuries	8
Fires without explosions	6
Explosions with/without fires	0
Fire burn injuries	4
Freeze burn injuries	4
Other injuries	0

Table 4
Incidents Reported for Gasoline Public and Private
Refuelling Stations in Ontario 1980-87

# Reported Incidents	364
Total Fires	20
Total Injuries	9
Fires without explosions	17
Explosions with/without fires	8
Fire burn injuries	8
Freeze burn injuries	Not applicable
Other injuries	1

Table 5
Incidents Reported at Propane Vehicle Conversion and Repair
Facilities in Ontario 1980-87

# Reported Incidents	7
Total Fires	7
Total Injuries	11
Fires without explosions	4
Explosions with/without fires	3
Fire burn injuries	10
Freeze burn injuries	0
Other injuries	1

vi. Injuries at propane public service stations were predominantly incurred by station personnel: injuries to members of the public (7 in total) accounted for only 16% of the total injuries. Four of the injuries to the public were due to improper sealing of the propane fill box, allowing propane to leak into the stationary vehicle during refuelling with subsequent ignition of the propane while the vehicle was within the service station boundary.

vii. As illustrated in Table 6, the frequency of incidents due to propane vehicle refuelling has decreased after reaching a peak in 1985. The number of vehicle refuelling incidents reported in 1986 and the first half of 1987 was about 50% of that reported for 1985 with somewhat greater reductions achieved in the number of fires reported, despite an increase in the fuel volumes sold.

viii. In contrast with vehicle refuelling the number of incidents in BBQ cylinder refilling operations, although a small proportion of the total, has increased over time. These incidents, though few in number, have been associated with a higher proportion of fires and fire burn injuries than in the vehicle refuelling operation.

2.2 Comparative Analysis of Propane Refuelling Incidents Among Jurisdictions

Although record-keeping levels and methods vary significantly among different jurisdictions and between propane and gasoline, the following facts are clear from comparison of incident data reported from Ontario, British Columbia, the Netherlands and U.S., where penetration of auto-propane is sufficient to provide a reliable incident database.

1. The incident rate at public propane service stations in Ontario is similar to that reported in British Columbia when allowance is made for the different number of propane-fuelled vehicles and service stations in the two provinces.

Table 6

Propane Incidents at Public Service Stations in Ontario 1980-87

	1980	81	82	83	84	85	86	87	Total
VEHICLE REFUELLING									
# Reported Incidents	0	4	2	4	4	10	5	3	32
Total Fires	0	5	2	3	3	7	2	1	23
Fire Burn Injuries	0	4	1	2	2	6	0	2	17
Other Injuries	0	0	0	2	1	2	3	2	10
CYLINDER FILLING									
# Reported Incidents	1	0	1	1	0	0	2	2	7
Total Fires	1	0	1	1	0	0	2	1	6
Fire Burn Injuries	1	0	0	1	0	0	3	1	6
Other Injuries	0	0	0	0	0	0	0	0	0
OTHER FUEL STORAGE & TRANSFER OPERATIONS									
# Reported Incidents	0	0	2	0	6	4	4	3	19
Total Fires	0	0	1	0	2	2	1	1	7
Fire Burn Injuries	0	0	1	0	4	0	0	1	6
Other Injuries	0	0	1	0	1	3	0	0	5
TOTAL									
# Reported Incidents	1	4	5	5	10	14	11	8	58
Total Fires	1	5	4	4	5	9	5	3	36
Fire Burn Injuries	1	4	2	3	6	6	3	4	29
Other Injuries	0	0	1	2	2	5	3	2	15

ii. Even after allowance is made for the higher volume of propane transferred to commercial vehicles at each refilling operation, the frequency of reported incidents at private refuelling stations is substantially lower than that at public refuelling stations. This reduced level also applies to the fires and injuries reported. In the period 1980-87, for example, only 11 incidents were reported at private refuelling centres, whereas 32 were reported for vehicle refuelling operations at public service stations, this despite the fact that private refuelling operations involved transfer of 1.8 times more propane than at public service stations. It appears that these differences may be attributed in some part to variations in the training of refuelling staff and awareness of safety.

iii. As measured by the number of injuries and fires reported, refuelling with propane at service stations in the Netherlands appears to be less incident-prone than similar operations in Ontario and British Columbia. The locations in the Netherlands have longer experience with auto-propane service than Canada and use substantially different refuelling equipment and practices. For example, elimination of the "spitter valve" on the in-vehicle propane storage tank and automation of the refuelling operation in the Netherlands have led to self-service propane refuelling for automobiles and an apparent low level of refuelling incidents compared to that achieved with Canadian equipment and a more manual refuelling operation. The number of incidents in the Netherlands has been sharply reduced from that prevailing before an intensive safety program was instituted by the fuel suppliers, new equipment introduced and government inspection penalities revised.

iv. Analysis of incidents at service stations in Ontario and British Columbia indicates that human error and deficiencies in training at these sites are major contributors. The analysis also shows

that the absolute number and the rate of refuelling incidents per station has decreased since 1985 as more experience has been gained by refuellers and improved training practices instituted.

v. Comparison of refuelling incidents at service stations in Ontario and British Columbia with those in the Netherlands indicates that some equipment used in Canada (such as the "spitter valve" and refuelling dispenser controls) could be improved and the improvement would likely lead to a reduction in the number of incidents, as noted in the Netherlands.

vi. A significant proportion (8 out of 32) refuelling incidents at public service stations in Ontario involved fires in catering vehicles with ignition traced to failure to shut off pilot lights in the cookers or refrigerators. Experience with catering vehicles outside Ontario is similar.

2.3 Incidents in Refilling of 20lb. (Barbecue) Cylinders

Filling of portable barbecue cylinders is a growing business at public service stations in Ontario, other Canadian provinces and most States in the U.S.A. In certain cities in the U.S. and in the Netherlands, cylinder refilling is prohibited at auto-propane vehicle refuelling centres. For example, only cylinder exchange is permitted in New York City. However, at other U.S. propane retail sales locations barbecue cylinder and recreational vehicle cylinder refuelling is the main outlet for propane rather than vehicle fuel sales. In contrast, the filling of small portable cylinders is not an important requirement in the Netherlands.

Key findings on incidents associated with cylinder refilling are:

i. The 7 incidents reported in Ontario in the period 1980-87 were associated with 6 fires and 6 injuries. No explosions or

fatalities were reported. The 6 injuries sustained were to company employees.

ii. No freeze burn injuries due to liquid propane were reported in the period. This may be due in part to the absence of the "splitter valve" as a requirement in Canadian portable cylinders.

iii. Public complaints (not included in the 7 incidents reported) concerning the odour of propane were seasonal, being principally associated with the purging of new cylinders at the beginning of the barbecue season. The odour emission may be due in some cases to the use of liquid propane in the cylinder purging process (rather than propane vapour, which is the correct procedure). Purging with liquid propane is prohibited by Ontario regulations.

2.4 Other Incidents at Public Propane Refuelling Stations

A category of incidents was recorded which was not related to vehicle refuelling or cylinder filling, but to other operations and equipment at the service station sites. The incidents included a vehicle collision with the dispenser, a leak during repair of a dispenser, a road tanker relief valve failure and failures at other valves and in transfer lines due to improper installation, operating errors and wear.

The 19 incidents reported in this category accounted for 7 fires and 11 injuries (6 fire burns and 5 freeze burns), none of which involved the public.

2.5 Incidents at Vehicle Repair and Conversion Facilities

Seven incidents were reported in Ontario in the period 1980-87 at vehicle repair and conversion facilities. The findings on these incidents are:

i. The most significant incident of this type in Ontario occurred during repair of a taxi on 17 November 1986 at a taxi garage located at 1295 Weston Road in the City of York. The accident was caused by a propane leak occasioned by severing of a fuel line during dismantling of propane equipment in a taxi that was being serviced by staff not certified for propane vehicle work at an unlicensed location. The fire and explosion injured the two involved employees (one had second and third degree burns to face and hands, the other minor burns to face and arm), severely damaged the garage and caused some broken windows and reported structural damage to a property within a radius of 100 metres. However, the explosion did not impair the integrity of the propane storage tank located at the site. The total value of the damage, including that to the garage, was estimated by the Fire Marshal's Office at $300,000. The garage owner was prosecuted by the Fuels Safety Branch and fined. The incident initiated reviews of by-laws on auto-propane and NGV storage, vehicle repair and conversions by the City of York and certain other municipal councils. Although the public and municipalities have expressed concern about propane storage tank setbacks, the explosion and consequent damage at the Weston Road incident was unrelated to the setback of the propane storage tank on that site.

ii. Incidents in the conversion of vehicles to propane are rare: the major source of incidents (6 of the 7 reported) were accidents during the repair or transfer of vehicle propane fuelling systems.

iii. Incidents involving vehicle conversion/repair were more severe than those associated with refuelling. Each of the incidents resulted in a propane fire, 3 of which were accompanied by an explosion. The Weston Road incident caused minor structural damage and broken glass outside the premises. The dollar value of damage to the conversion premises in these instances was substantially higher than for open air incidents at service stations.

iv. The incidents did not lead to leaks or other incidents involving propane tanks and other refuelling equipment which were on site.

v. Incidents within propane vehicle repair and conversion shops also resulted in a higher level of injuries than incidents at propane service stations: 11 injuries (10 fire burns) being reported in 1980-87. No injuries to the public were reported.

vi. The incident rate at propane vehicle conversion/repair shops in Ontario is not higher than than reported in British Columbia.

More information is required on means available to reduce the frequency and severity of incidents at propane vehicle conversion/repair shops. Improved ventilation to prevent accumulation of propane vapour, and use of leak detections systems and explosion panels may be indicated. Improvements in the training and supervision of personnel employed at conversion and repair shops may also be indicated.

3. NGV REFUELLING AND VEHICLE CONVERSION INCIDENTS

Ontario Incident Data: No fires or injuries at NGV refuelling stations have been reported in Ontario, and only one incident in Table 7 has been reported at an NGV fuelling station in Ontario.

Canada-wide Incident Data: The current low level of NGV use does not provide a statistically significant database for determining the level of incidents at NGV fuelling stations or at NGV conversion and repair facilities. Information on NGV incidents on a national basis is therefore taken from engineering records provided to Energy, Mines and Resources Canada as part of the requirements for grants made under the Natural Gas Refuelling Station Program.

Twenty-six incidents at NGV stations since 1982 were reported throughout Canada. None involved fatality or injury. The number of incidents reported has decreased over the period, only one being reported in 1987. The sources of incidents are summarized in Table 7. One of the incidents was reported by Ontario NGV station owners - a gas

6.2.3 Portable CNG Cylinders

A business is developing in Ontario involving the refilling of portable cylinders with compressed natural gas for marine application. This application of compressed natural gas is under review by the Fuels Safety Branch for inclusion in the Ontario regulations.

6.3 Gasoline

Aside from a much-publicized recent fatality at a Vancouver service station, the adequacy of safety regulations, employee training and code enforcement at gasoline stations in Canada has not been disputed. Ontario regulations on gasoline storage and transfer have been modified from time to time to maintain the excellent safety record for this fuel in the province. It must be recognized, however, that gasoline like propane and NGV is a combustible hydrocarbon fuel and as such must be handled in accordance with prescribed standards and regulations.

7. PUBLIC CONCERNS AND PERCEPTIONS

7.1 Perceptions of Safety

The publicity attending the Mississauga rail tanker derailment in 1979 involving releases of chlorine and propane, the Weston Road incident, and other incidents outside Ontario and Canada where there were fires and property damage due to propane or natural gas have heightened public concern about the safety of alternative fuels, but do not seem to have raised the level of public concern regarding the hazards also attendant upon the storage and use of the more common liquid fuels such as gasoline and fuel oil.

leak caused by a broken fitting. The fire reported was in Quebec but not associated with natural gas. One fire without injury has been reported at a conversion shop in British Columbia.

Table 7

Canadian NGV Fuelling Station Safety Incidents 1982-87

Gas leak	12
Relief valve opened on compressor	8
Broken gas main	0
Refuelling line	1
Fire (solvent fire, not related to NGV)	1
Other	4
TOTAL	26

New Zealand Incident Data: In New Zealand, where use of NGV is extensive, detailed reporting of leaks and other incidents is required. Records there, as in Canada, show a number of gas leaks experienced during the start-up phase of new facilities due to malfunction of valves at the dispenser and problems with compressors. No such incidents were reported in Canada since 1983.

4. GASOLINE SERVICE STATION INCIDENTS

The major source of reported incidents at gasoline refuelling stations is fuel leakage from underground storage tanks. These constitute an environmental, rather than an immediate safety hazard. However, incidents have been reported in the U.S.A. where the leaked gasoline has travelled underground, accumulated in the basement of a building and ignited, in some instances with an explosion.

A regulation concerning the underground storage of gasoline, diesel and fuel oil has been issued in Ontario and the petroleum industry has an active program of tank replacement underway in the province. Leaks from underground storage tanks accounted for 172 of the 364 incidents reported by the Fuels Safety Branch of Ontario in the 1980-87 period. The incident rate, including underground leaks, corresponds to one incident for each 233 million litres sold in the period 1980-87. In 1986, the 49 reported incidents corresponded to one incident at 161 public service station locations or 1 at 226 locations, if the underground tank leaks are omitted.

Dealing only with fuel transfer, incidents at gasoline stations resulted in 20 fires, 8 explosions and 9 reported injuries (8 fire burns) in 1980-87. A higher proportion (75% of identified cases) of injuries at gasoline service stations were sustained by the public than in propane refuelling cases, due to the high proportion of self-service refuelling of gasoline and the Ontario requirement that propane refuelling be made by a trained company refueller, not by the public.

5. RISK ASSESSMENT STUDIES

5.1 Current Sources of Information

Risk assessment is an emerging tool used to investigate safety strategies and equipment. Risk assessment studies on propane in Canada have focussed on incidents involving rail movement of the commodity. Centres elsewhere have developed and applied risk assessment methodologies to the evaluation of propane storage and transfer at service stations and comparisons of propane risks with those for NGV and gasoline. For example, two studies conducted by the Netherlands Organization for Applied Scientific Research (TNO) have provided quantitative assessment of risks involved at service stations transferring propane and gasoline in the Netherlands and New Zealand.

Another study conducted by a group at the Los Alamos National Laboratory in the U.S.A. has provided expert, but qualitative assessments of the relative risks involved in certain types of incidents involving propane, NGV and gasoline at refuelling sites and vehicle garages. The general findings from these studies are relevant to the GIC investigation.

5.2 TNO Risk Assessment Findings

The Dutch study indicates that:

i. Propane incidents are more frequent and more severe (incidence of fire and injuries) than gasoline incidents.

ii. The majority of propane incidents involve fuel transfer from the storage tank to the vehicle: they occur at the fuel dispenser, at the transfer hose and at the vehicle being refuelled.

iii. The area within which fire injury will be possible in these incidents is limited: the worst condition gives a radius of 100-130 feet from the source of this type of propane leak.

iv. Other possible propane incidents at service stations have a very low probability of occurrence (in the range of one incident per station each 10,000-200,000 years or higher), but could lead to fire injuries and property damage beyond any feasible separation distance. Incidents of this rare type are:

- failure of the transfer line from the road tanker to the bulk storage tanks while propane is being transferred to storage (according to TNO calculations, this may be expected to occur once in 10,000 years at a given site)

- sudden failure of the road tanker with release of propane and explosion occasioned by a fire or collision at the tanker (TNO

calculations give a frequency of once in 50,000 years at the site for this type of incident - termed a BLEVE - see Glossary of Terms). It should be noted that road tanker design and practice are different in Canada and the Netherlands and that road tanker regulations and construction have been changed significantly in recent years to minimize the possibility of tank failure. The TNO calculations are based upon incidents reported world-wide over a 30-year period.

- failure of the bulk storage tank on site due to fire or other damage causing rupture of the tank (frequency of once in 100,000 years was calculated for this type of BLEVE).

v. The likelihood of catastrophic storage tank failures is reduced essentially to zero if the tank is buried or mounded, but the frequency of aboveground tank failures is so low that tank burial has not been universally adopted. Furthermore, burial of tanks introduces a new problem of control of tank corrosion.

vi. Overall safety at propane refuelling stations is improved if larger storage tanks are used, resulting in fewer road tanker trips and a reduced number of fuel transfers from these tankers to the storage facility.

vii. The potential for injuries and fatalities from propane refuelling is no higher than that accepted by the public and employees for a number of other conveniences and occupations. Interpretation of the Dutch study is that the possibility of a fatality to a member of the public from a propane refuelling incident involving rupture of a storage tank is less than that from electrocution in the home (once in 200,000 years for an individual or one fatality per year among 200,000 persons) and less than fatalities to pedestrians from passing motor vehicles (once in 100,000 years for a pedestrian).

Figure 1 illustrates the maximum area and effect of propane incidents at service stations which should be compared with those given in Figure 2 for gasoline.

5.3 Findings from the Los Alamos Study

The Los Alamos study issued in 1983 provided the opinion of a group of experts on the comparative safety of gasoline, propane, NGV, LNG and diesel fuel in a series of incident scenarios, including those found in refuelling, garaging and on-highway operation of vehicles. The Los Alamos study is based upon the equipment and technology used in the U.S. before 1983 and the conclusions drawn on gasoline, propane and NGV may not be applicable to Canada in 1987-88, since Canadian technology has improved greatly since 1983, particularly with respect to safety. The principal value of the Los Alamos study now lies in the methodology that was developed to infer the relative safety of the fuels from consideration of their fundamental properties, the equipment used to store and transfer the fuel and the type of incident. The study also provided a set of criteria for the safe handling of propane and NGV.

Three conclusions are drawn from the Los Alamos study:

i. The difference in physical properties of the fuels has a great effect on the likelihood of occurrence of a fuel leak, or spill, as well, the properties of the liquid spilled has also an impact on the severity of personal injury, fire or explosion.

ii. Ventilation is a key factor in reducing the likelihood of incidents in closed areas such as garages. Improved ventilation may similarly be expected to improve safety in vehicle repair and conversion shops.

Figure 1

Maximum Distance and Effect of Incidents at Propane Service Stations

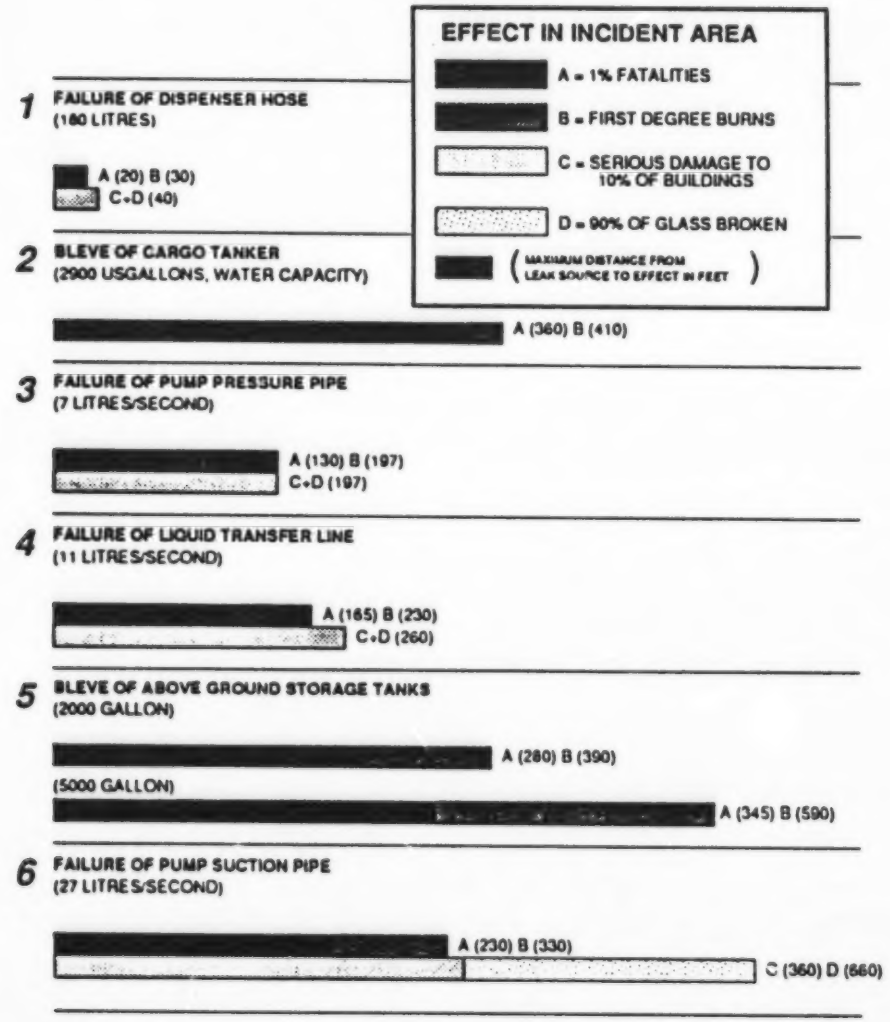
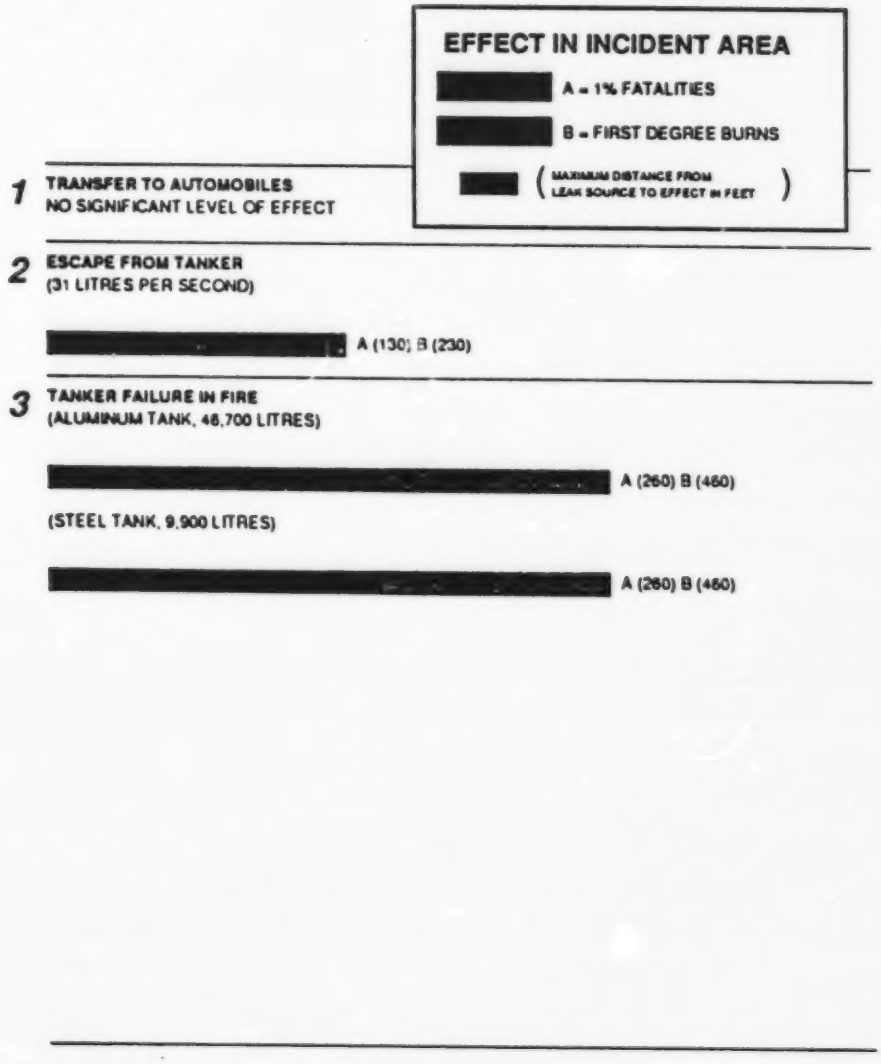

EFFECT IN INCIDENT AREA
A = 1% FATALITIES
B = FIRST DEGREE BURNS
C = SERIOUS DAMAGE TO 10% OF BUILDINGS
D = 90% OF GLASS BROKEN
(MAXIMUM DISTANCE FROM LEAK SOURCE TO EFFECT IN FEET)
1 FAILURE OF DISPENSER HOSE (180 LITRES)
A (20) B (30)
C+D (40)
2 BLEVE OF CARGO TANKER (2900 USGALLONS, WATER CAPACITY)
A (360) B (410)
3 FAILURE OF PUMP PRESSURE PIPE (7 LITRES/SECOND)
A (130) B (197)
C+D (197)
4 FAILURE OF LIQUID TRANSFER LINE (11 LITRES/SECOND)
A (165) B (230)
C+D (260)
5 BLEVE OF ABOVE GROUND STORAGE TANKS (2000 GALLON)
A (280) B (390)
(5000 GALLON)
A (345) B (590)
6 FAILURE OF PUMP SUCTION PIPE (27 LITRES/SECOND)
A (230) B (330)
C (360) D (660)

Figure 2

Maximum Distance and Effect of Incidents
at Gasoline Service Stations


EFFECT IN INCIDENT AREA
A = 1% FATALITIES
B = FIRST DEGREE BURNS
(MAXIMUM DISTANCE FROM LEAK SOURCE TO EFFECT IN FEET)
1 TRANSFER TO AUTOMOBILES
NO SIGNIFICANT LEVEL OF EFFECT
2 ESCAPE FROM TANKER
(31 LITRES PER SECOND)
A (130) B (230)
3 TANKER FAILURE IN FIRE
(ALUMINUM TANK, 46,700 LITRES)
A (260) B (460)
(STEEL TANK, 9,900 LITRES)
A (260) B (460)

iii. An updated study using the Los Alamos methodology and current Canadian technology would provide a further insight into the relative safety of gasoline, propane and NGV.

5.4 Assessment of Risks in Ontario

The development of a self-supporting risk assessment of refuelling stations, conversion and repair shops in Ontario requires a schedule and budget beyond that available for the present investigation. The TNO risk assessment studies in the Netherlands and New Zealand have provided a methodology which could be applied to an assessment of propane and gasoline refuelling risks in Ontario. The incident database in Ontario is too small to provide a rigorous statistical analysis: the Dutch and New Zealand assessments required use of certain equipment failure data from other countries. The uniqueness of Canadian climatic conditions and of the Canadian equipment, training and legislation will complicate adoption of foreign databases in a meaningful Ontario safety assessment. The route chosen in the present investigation was therefore to interpret the previous studies where they could be used.

No risk assessment studies were available for NGV refuelling or for the conversion of vehicles to NGV or propane. A new methodology will be required and an extensive database on equipment performance, reliability, and incidents must be assembled. Until such an undertaking is complete no quantitative assessment of NGV refuelling and vehicle conversion can be given and reliance must be placed on the qualitative analysis of the limited incident data available.

6. REGULATIONS

Here are summarized only those regulations in Ontario which are relevant to the siting and setback issues and those in place outside Ontario which may provide guidance on these issues.

6.1 Propane

The Ontario regulations on public propane service stations have been developed using the Canada Standard as a basis, which in turn has been developed along lines similar to those contained in standards issued by the U.S. National Fire Protection Association. Other countries have a variety of regulations and standards for the separation of propane storage tanks from property lines, other storage tanks containing propane or gasoline and from buildings on site.

6.1.1 Propane Refuelling Stations

Great differences exist world-wide in the level of municipal and community participation in propane service station site approvals. Ontario is at the mid-point with joint planning of sites undertaken by the municipalities and the Fuels Safety Branch. Emphasis in the regulations has shifted from the original intent of providing separation distances adequate to protect facilities and fuel at propane refuelling or storage sites from radiant heat (fire) sources on site or on adjacent property to an emphasis on protection of the public and adjacent property from incidents which occur at propane transfer sites.

Tank Size Considerations

The maximum size of an auto-propane storage tank at public sites in Ontario is 5,000 gallons (U.S. gallons, water capacity of the tank). Prior to 1982 the maximum size was 2,000 gallons. Some 68% of the storage tanks at public service stations in Ontario still have capacity of 2,000 gallons or less.

In the U.S. special protection and a fire safety analysis are required if propane storage is in excess of 4,000 gallons. It is reported that 50% of the storage tanks at public service stations have capacity of 1,000 gallons or less. Auto-propane sales constitute a

smaller proportion of retail sales in the U.S. than in Canada and the small U.S. storage tank size reflects this market difference.

In contrast, in the Netherlands regulations require that storage tanks at new public service stations be buried and of a capacity not less than 5,300 gallons and not more than 10,600 gallons. The selection of a high level for the minimum size of storage in the Netherlands is based upon reducing the frequency of filling the stationary storage tanks from road tankers, the high propane throughput of the service stations in that country and the excellent safety record of the buried, large storage tanks.

Separation of Tanks from Adjacent Property

Regulations in the Netherlands provide a formula for determining the separation distances between propane tanks and dispensers from adjacent property. The separation distances vary with the type of use and the imputed level of occupancy of the adjacent population-sensitive property. The new separation distances were arrived at by use of the TNO safety assessment methodology previously noted.

In Ontario, the current separation distance regulations affecting auto-propane service stations do not recognize differences in the use and implied occupancy of adjacent property. In contrast, the Ontario regulations governing the storage of propane cylinders at cylinder filling locations do provide for separation distances from the cylinder storage area which vary with the type of occupancy in adjacent property. The national committee responsible for the development of Canadian standards for propane (known as the "B149 committee") is investigating a code which would relate tank separation distances from adjacent property on the basis of the type of use of the adjacent property and population density. Ontario is represented on this committee.

Separation distances required in Ontario were reduced in 1982. Similar reductions were adopted by the Canadian Standard B149.2 M86 when it was published in 1986. As an example, for a 2000 gallon tank the separation distance was reduced from 25 feet to 10 (7.6 to 3 metres). This decrease in separation was undertaken to encourage propane supply at existing gasoline refuelling stations and in areas where the previous 25 feet separation distance inhibited construction of a propane station. However, the reduction was limited to sites where special fire protection or a non-combustible wall was available and did not increase the risk to the occupant of adjacent property.

Record Keeping

In the Netherlands station owners must maintain detailed log books on the installation, staff, equipment changes and suppliers for use by government inspectors. Although the major propane suppliers in Canada require that detailed records of fuel movements be maintained and the Fuels Safety Branch requires that suppliers audit and report on safety at refuelling stations annually, the record requirements in Ontario are substantially less onerous than those in the Netherlands.

6.1.2. Propane Vehicle Conversion and Repair Shops

Ontario regulations on conversion facility licencing and employee certification reflect best practice and compare favourably with regulations outside the province.

Some jurisdictions outside Ontario employ other techniques to maintain quality and safety in conversions. In British Columbia conversion shops must be bonded - thereby placing a responsibility upon the bonding company. In the Netherlands there are numerous controls, including the mandatory de-certification of sites where a minimum number of conversions are not achieved and those where a number of conversions are not approved by government inspectors in a given period. Also in the Netherlands more than one employee with conversion training (one certified by the state) is required at each conversion site. Random

vehicle inspections are conducted: a minimum number of inspections of each site is required each year.

It may be noted that Ontario introduced a regulation requiring the testing of installed propane conversion equipment using pressurized inert gas which was subsequently adopted as a National Standard by the "B149 Committee".

6.2 Natural Gas

6.2.1 NGV Refuelling Stations

NGV stations in Ontario must be built in accordance with the National Standard which is the basis for a draft of the pending Ontario Code. The Fuels Safety Branch monitors safety at these NGV stations according to the National Standard. However, regulations specific to NGV service stations and conversion shops are not yet in force in Ontario. This reflects the low level of NGV use until recently in Ontario and the existence of provincial regulations on the use of natural gas for heating and other purposes which provide an implicit level of regulation on NGV storage and transfer.

Natural gas is delivered to the service stations through underground pipelines and compressed on site. The volume of compressed gas stored in high pressure cylinders does not exceed the fuel equivalent of 150 gallons of gasoline. The vehicle refuelling process is a closed system so that fuel release on connecting or disconnecting the refuelling probe is extremely small.

The separation distances used at service stations in Ontario and the National Standard are consistent with those used in New Zealand and the U.S.A. In contrast, regulations in Italy are very restrictive with unusually large separation distances and location limitations in force which reflect pre-1950 concepts and the pioneering of NGV markets and

regulations in Italy at that time. Since NGV is sold only at dedicated NGV service stations, and regulations are being revised there, Italy cannot serve as a regulation model for the separation distances in Ontario, despite the fact that more than 350,000 NGV vehicles are reported to be currently in service in that country.

Separation distances in Ontario between property lines and compressors, NGV storage cascades and dispensers do not currently reflect the level of occupancy of adjacent property, but have a mechanism for the provision of special protection for restricted sites where separation distances can be reduced if a fire-resistant wall is employed. For example, the separation distance between a property line and aboveground NGV storage cylinders can be reduced from 10 feet to 3 feet by introduction of an intervening fire-resistant wall: typically a masonry wall is used to protect the facility from radiant heat sources on the adjacent property. Use of a fire-resistant wall could be an alternative to varying the separation distances between NGV storage facilities, compressors, refuelling islands and adjacent structures if legislation is required which responds to the level and type of occupancy of structures on properties adjacent to the NGV station.

6.2.2 NGV Conversion and Repair Shops

The regulations on NGV conversion and repair facilities and personnel in New Zealand are well developed and similar to those in place in New Zealand and Ontario for propane conversions. In contrast, in Ontario regulations on conversion site licensing and employee certification are pending. In the interim, the National Standard is being applied.

A leak test procedure is required on vehicles converted to NGV according to the National Standard. This leak test is conducted with an inert gas before NGV is introduced into the vehicle, thus reducing the potential for NGV leaks.

Due to the recent introduction of alternative fuels technology into Canada, there is a lack of public experience, knowledge and understanding of propane and NGV with many non-users of these fuels being unable to distinguish between the names and abbreviations. Thus, LPG (known variously as liquefied petroleum gas or propane), NGV (natural gas for vehicles), CNG (compressed natural gas) and LNG (liquefied natural gas, which is not used in vehicles) are frequently confused, as is the understanding of the properties and safety records of these fuels.

No fatalities from the alternative fuels have been recorded in Ontario in the period since propane and NGV were first used and accidents and injuries involving the public at refuelling and service stations have been few, a total of only 7 injuries from propane were reported in the period 1980-87. Nevertheless, public perception of safety is at variance with the record. The experience in the Netherlands at the peak of auto-propane growth in that country was similar, but has since been improved following changes made to reduce the visibility of auto-propane storage facilities, improvements in equipment at service stations, by changes in the regulations and joint industry-government effort to improve the understanding of the fuels and benefits among the public and their municipal representatives. This underlines the fact that resolution of risk issues is a social and political process as much as a technical process.

Industry and government in Ontario still need to create an understanding of the benefits as well as the technology and safety record of propane and NGV among the users and non-users of these fuels in Ontario, which understanding will improve their perception and acceptance of conveniently sited propane and NGV stations.

7.2 Nuisance Issues

The principal nuisance cited by the public for propane is the

odour. This is due in major part to the improper purging of new cylinders at the start of the barbecue season. Propane and NGV have no odour: a stenching agent is deliberately added in regulated amounts to permit detection of gas or propane leaks before the concentration of gas or propane reaches the flammability limit. Lower levels of stenching agent may reduce the complaints about odour at service stations but are not advisable, since U.S. studies have shown that many older people lose their sensitivity to the smell and a reduced odourant level would have safety implications.

Other complaints relate to the increased level of traffic at stations which adopt propane and/or NGV, but since NGV and auto-propane replace gasoline sales, this effect is essentially a redistribution of service station activity among the pool of service stations.

Complaints regarding equipment noise are usually specific to pump design and location. The noise can be reduced by equipment changes. This is not a safety issue.

8. KEY ISSUES AND FINDINGS

8.1 Public Propane Service Stations

The frequency of injuries, fires and property damage at public service stations has lessened in recent years but can be further improved. The reported statistics suggest that current refuelling practices at private stations are significantly safer than those at public service stations. However, there are differences in the modes of operation and a simple comparison of the incident statistics may be misleading.

Notwithstanding the possible effect of incomplete and unreliable data on incidents involving gasoline, Ontario and world-wide experience

shows that propane equipment and/or personnel at public refuelling stations have not yet reached the level of safety achieved and accepted with gasoline. The high proportion of injuries to station employees (certified refuellers) indicates that the current equipment and training and enforcement programs can be improved. Outside Canada this responsibility is most frequently placed entirely upon the station owners - the government role being primarily to ensure compliance through inspections of facilities and station records.

The low level of injuries to the public is noteworthy, as is the fact that no instances were found in the current investigation where accidents at public propane refuelling stations caused injury to the public or damage to property outside the service station. (The Weston Road incident was not due to propane refuelling and occurred when a propane system on a taxi was being removed).

Experience and safety assessment studies show that the frequency of catastrophic fires due to failure of on-site propane storage tanks is so low that tank burial or mounding will not significantly change the already excellent safety record of these units.

Despite this, prudence and the public perception of the safety of propane storage tanks may suggest that in the future storage tanks at service stations be restricted in size unless buried or otherwise protected and that the change in permissible separation distance from the tank to the property line be reassessed.

The issue of variation in the separation distance of propane facilities from properties with different population density and type of use (residential, high rise, school, hospital, etc.) may warrant further investigation. If so, this could involve investigation of the separation distance between the dispenser and occupied buildings on adjacent property, as well as building separations measured from the propane road tanker and its transfer hose.

It should be borne in mind that because the most frequent incidents do not affect people or property outside the service station area, measures to adopt very large separation distances for protection against even the extremely rare types of incident (such as storage tank or road tanker failures) would insignificantly reduce the already low risk of injuries to the public and already low risk of damage beyond the service station property line.

The injuries to company refuelling staff at service stations can be traced in part to the continued use of equipment which, though currently approved by Ontario regulation and Canada codes, has been superseded in certain other countries by systems with higher intrinsic safety potential. Since technical development frequently precedes standards development, it is incumbent upon the industry and regulators to maintain a high level of awareness of these developments, whether they occur in Canada or elsewhere. For example, attention might be given to the advisability of the continued use of "spitter valves" in new in-vehicle propane tanks and to the adoption of alternative designs of dispenser controls and refuelling nozzles to improve safety where these changes have been shown elsewhere to provide added protection during refuelling.

The public perception of propane as a vehicle fuel could be improved by a long term information and awareness program. Public perception of the hazards of propane could be improved and the frequency of complaints reduced by changes at the service stations, such as the visual screening of storage tanks.

8.2 Portable Barbecue Cylinder Filling

The potential for propane spills and related fire incidents at public service stations is increased when a high level of portable cylinder filling is also conducted. The safety of service station personnel would be somewhat improved and the number of complaints

regarding odour reduced if portable cylinder filling were discontinued at stations close to congested residential areas. A cylinder exchange program would achieve this while also providing an improved level of cylinder inspection and maintenance when filling is conducted at an approved dedicated site. Cylinder exchange is a common practice outside Canada and cylinder exchange is used within Canada for the supply of propane to fork-lift trucks and other industrial vehicles.

8.3 NGV Refuelling

The experience level with NGV refuelling in Ontario is insufficient to draw conclusions on the adequacy or inadequacy of current refuelling practices.

In view of the small volume of hydrocarbon stored at the NGV stations and the excellent safety record achieved to date it would seem to be inappropriate to apply the separation distances and siting restrictions developed for auto-propane to NGV.

Public perception of NGV could be improved by a public awareness program and by changes at the refuelling sites, such as visual screening of the compressor unit and storage area.

8.4 Vehicle Conversions

Though few in number, incidents involving repair and conversion of propane vehicles were severe in terms of injuries and property damage compared to incidents reported at service stations. Property damage in conversion/repair shop incidents has extended to private property outside the conversion premises and therefore has a high public visibility compared to refuelling site incidents. However, incidents at service stations include a number which can be partly attributed to improper vehicle conversion.

Incidents involving vehicles indicate a need for improved training and supervision of conversion mechanics. The current process of requiring certification of mechanics and inspectors is important but could be augmented by practical experience and supervision. Measures taken outside Ontario to improve safety include bonding of conversion shops and a licencing procedure which eliminates shops with low conversion activity and a poor quality record. Additional measures to reduce the frequency and severity of accidents at conversion shops could include a requirement for leak detectors, area ventilation and installation of explosion panels.

Regulations to require certification of NGV conversion shops and mechanics are pending.

The requirements for training and supervision of mechanics and the opportunity for incident reduction through use of alarms and ventilation equipment could be included in the new Ontario regulations for NGV.

APPENDIX - GLOSSARY OF TERMS USED

Ambient (temperature, pressure): surrounding the facility, prevailing.

Auto-propane: Propane used in automobiles and which, in Canada, must meet stringent composition regulations.

BLEVE: An acronym for Boiling Liquid Expanding Vapour Explosion. An explosion of propane or gasoline that is suddenly transformed into vapour or heated liquid after failure of the storage tank. The event is usually accompanied by formation of a fireball.

Cascade: An assembly of cylinders for the storage of compressed natural gas (NGV).

Conversion Shop: A location where vehicles are converted from the exclusive use of gasoline (or diesel) to vehicles which can operate on propane, propane and gasoline, or NGV and gasoline.

Explosion: A sudden and violent expansion caused by the rapid burning of gasoline, natural gas or propane in air. The expansion is accompanied by a noise, a shock wave and the liberation of large amounts of heat.

Fuel Transfer: Transfer of propane, NGV or gasoline between a vehicle and fuel storage tank. Examples are vehicle refuelling from a storage tank and dispenser and transfer of propane from a road tanker to the storage tank at a refuelling site.

Incident: An event which causes, or has the potential to cause, an escape of gasoline, propane or natural gas which may be ignited or not.

Incident Rate: The frequency of occurrence of incidents.

Leak: An escape of gasoline, propane or natural gas from a crack, hole or faulty closure.

LPG: Liquefied petroleum gas - another term for propane.

NGV: Natural gas for vehicles - compressed natural gas.

Private Refuelling Facilities: Privately-owned facilities where company-owned and other fleets of vehicles are refuelled. These facilities do not retail fuel to the public.

Public Refuelling Facilities: Service stations where vehicle fuels are dispensed to the general public.

GLOSSARY CONTINUED

Purging: The process by which air is displaced from new and existing propane storage cylinders, using propane vapour before filling with liquid propane.

Reported Incident: Any incident which is reported to authorities outside the gasoline, propane or natural gas fuel transfer site and/or gasoline, propane or natural gas vehicle conversion or repair centre. Authorities outside the fuel transfer site or vehicle conversion or repair centres/sites include: Ontario Ministry of Consumer and Commercial Relations, Fuels Safety Branch; Office of the Fire Marshal; local/municipal fire department; local police department; other municipal agencies; Ontario Ministry of the Environment; insurance agencies.

Retail: The selling of propane, NGV, gasoline to the ultimate consumer as distinguished from wholesale. In general, retail sales of gasoline, propane and NGV are made at public service stations.

Spitter Valve: A valve which is required to be incorporated in propane storage tanks which emits propane when the tank is filled to the maximum allowable fill point. (80% in Canada for in-vehicle auto-propane tanks). Also known as a 'spit valve' '80% fill valve' or 'ullage valve'.

Stenching Agent: A sulphur-containing material which is added to propane and natural gas to facilitate detection of leaked material.

20lb. Cylinder: A portable cylinder normally used for the storage and transport of propane and is most commonly used as the container for propane used in barbecues.

B149 Committee: This committee is composed as required by the Standards council of Canada and includes members from the regulatory authorities, manufacturers, gas utilities and propane companies, and its purpose is to develop and update the national codes namely the Gas Utilization Code, the Propane Storage Handling and Utilization Code.